(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 472 727 A1**

(12) **EUROPEAN PATENT APPLICATION published in accordance with Art. 158(3) EPC**

(21) Application number: **90907459.3**

(51) Int. Cl.5: **H01S 3/1055**

(22) Date of filing: **18.05.90**

(86) International application number: **PCT/JP90/00639**

(87) International publication number: **WO 90/14704 (29.11.90 90/27)**

(30) Priority: **18.05.89 JP 124898/89**

(43) Date of publication of application: **04.03.92 Bulletin 92/10**

(84) Designated Contracting States: **DE**

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(54) **NARROW-BAND OSCILLATION EXCIMER LASER.**

(57) A narrow-band oscillation excimer laser employing a diffraction grating as a wavelength selecting element, which is particularly suited for a light source of a reduction type projection aligner. The grating used in the narrow-band oscillation excimer laser of the invention is so disposed that the direction of grating lines is nearly perpendicular to the direction of laser discharge. When a beam expander is used to expand laser beam falling on the beam expander is so disposed that the direction of beam expansion is nearly perpendicular to that of discharge of the laser. Further, when an aperture is to be used in the optical resonator, the aperture is placed so that the longitudinal direction may be parallel to the direction of laser discharge. Moreover, the front mirror of the optical resonator is a cylindrical one, whose mechanical axis is in parallel with the direction of laser discharge. This makes it possible to provide a narrow-band oscillation excimer laser having very high efficiency and excellent durability.

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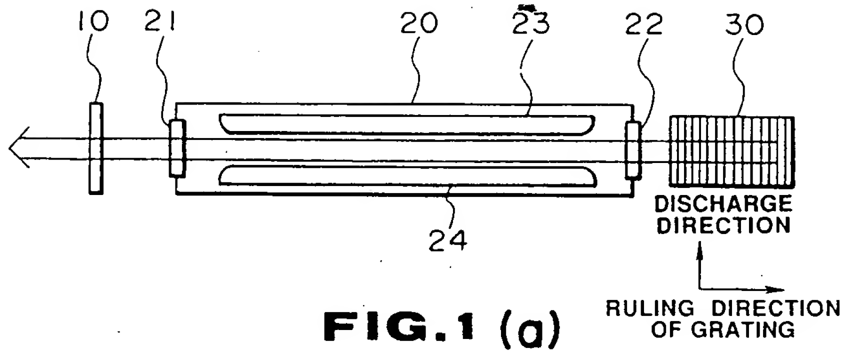

10
21
20
23
22
30
24
DISCHARGE DIRECTION
RULING DIRECTION OF GRATING

FIG.1 (a)

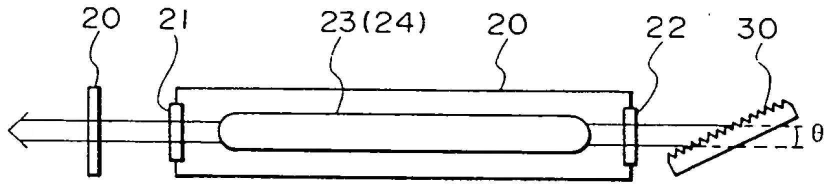

20
21
23(24)
20
22
30
θ

FIG.1 (b)

FIELD OF ART

This invention relates to a narrow band excimer laser, and more particularly a narrow-band excimer laser suitable for use as a light source of a reduction projection aligner.

BACKGROUND ART

An attention has been paid to the use of an excimer laser as a light source of reduction projection aligner (hereinafter called a stepper) for manufacturing semiconductor devices. This is because the excimer laser may possibly extend the light exposure limit to be less than 0.5 μm since the wavelength of the excimer laser is short (for example the wavelength of KrF laser is about 248.4 nm), because with the same resolution, the focal depth is greater than a g line or an i line of a mercury lamp conventionally used, because the numerical aperture (NA) of a lens can be made small so that the exposure region can be enlarged and large power can be obtained, and because many other advantages can be expected.

An excimer laser utilized as a light source of the stepper is required to have a narrow bandwidth with a beam width of less than 3pm as well as a large output power.

A technique of narrowing the bandwidth of the excimer laser beam is known as the injection lock method. In the injection lock method, wavelength selecting element (etalon, diffraction grating, prism, etc.) are disposed in a cavity of an oscillation stage so as to generate a single mode oscillation by limiting the space mode by using a pin hole and to injection synchronize the laser beam in an amplification stage. With this method, however, although a relatively large output power can be obtained, there are such defects that a misshot occurs, that it is difficult to obtain 100% the locking efficiency, and that the spectrum purity degrades. Furthermore, in this method, the output light beam has a high degree of coherency so that when the output light beam is used as a light source of the reduction type projection aligner, a speckle pattern generates. Generally it is considered that the generation of speckle pattern depends upon the number of space transverse modes. When the number of space transverse modes contained in the laser light is small, the speckle pattern becomes easy to generate. Conversely, when the number of the space transverse modes increases, the speckle pattern becomes difficult to generate art. The injection lock method described above is a technique for narrowing the bandwidth by greatly decreasing the number of space transverse modes. Since generation of speckle pattern causes a serious problem, this technique can not be adopted in the reduction type projection aligner.

Another projection technique for narrowing the bandwidth of the excimer layer beam is a technique utilizing a air gap etalon acting as a wavelength selective element. A prior art technique utilizing the air gap etalon was developed by AT & T Bell Laboratory wherein an air gap etalon is disposed between the front mirror and a laser chamber of an excimer laser device so as to narrow the bandwidth of the excimer laser. This system, however, cannot obtain a very narrow spectral bandwidth. In addition there are problems that the power loss is large due to the insertion of the air gap etalon. Further it is impossible to greatly increase the number of the space transverse modes. Furthermore, the air gap etalon has a problem of poor durability.

Accordingly, an excimer laser device has been proposed wherein a relatively high durable diffraction grating is used as the wavelength selective element. However, in the prior art device utilizing the diffraction grating, there is a problem in the manner of utilizing it so that it is impossible to efficiently reduce the bandwidth.

As above described, the prior art excimer laser device have problems in narrowing the bandwidth, output power, the number of the space transverse modes, or durability so that it has been impossible to use the conventional excimer laser devices as the light source of a stepper.

Accordingly, it is an object of this invention to provide a narrow-band oscillation excimer laser device utilizing a diffraction grating as a wavelength selecting element and capable of efficiently reducing the bandwidth.

DISCLOSURE OF THE INVENTION

In the narrow band excimer laser, it is so arranged that the ruling direction of the grating is substantially perpendicular to the discharge direction of the laser.

Where a beam expander is used to expand the light beam irradiating the grating, the beam expander is arranged such that its direction of beam expanding is substantially perpendicular to the laser discharge direction.

Where an aperture is disposed in a light resonator (laser cavity), the aperture has elongated sides in parallel with the direction of discharge of the laser device.

Further, the front mirror of the light resonator is of a cylindrical mirror with its mechanical axis being coincide (parallel) with the laser discharge direction.

In an excimer laser device, the beam expanding angle is larger in the discharge direction of the laser device than in a direction perpendicular to the

discharge direction, so that by making the ruling direction of the grating to be substantially perpendicular to the discharge direction of the laser device, it is possible to efficiently narrow the bandwidth.

Also by making the beam expanding direction of the beam expander to be substantially perpendicular to the discharge direction of the laser device, the efficiency of narrowing the bandwidth can be improved.

Further, by making the aperture disposed in a light resonator as having longer sides in parallel with the direction of discharge of the laser device, the efficiency of narrowing the bandwidth can be improved.

Furthermore, by using for the front mirror of the light resonator a cylindrical mirror with the mechanical axis of the cylindrical mirror being coincide with the discharge direction of the laser device, the efficiency of narrowing the bandwidth can be further improved.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1a and 1b are a side view and a plan view respectively showing one embodiment of this invention in the form of a Littrow mount;

Figs. 2a and 2b are a side view and a plan view respectively of another embodiment of this invention in the form of grazing incidence mount;

Figs. 3a and 3b are a side view and a plan view respectively showing a still another embodiment in the form of Littrow mount with a prism beam expander;

Figs. 4a and 4b are a side view and a plan view respectively showing a further embodiment of this invention in the form of Littrow mount with a beam expander made up of a cylindrical lens;

Figs. 5a and 5b are a side view and a plan view respectively showing a still further embodiment of this invention in the form of grazing incidence mount with a prism beam expander;

Figs. 6a and 6b are a side view and a plan view respectively showing a yet another embodiment of this invention in the form of grazing incidence mount with a cylindrical lens beam expander;

Figs. 7a and 7b are a side view and a plan view respectively showing another embodiment of this invention wherein apertured members are used;

Fig. 8 is an end view of the embodiment shown in Fig. 7 as seen in the direction of the front mirror;

Fig. 9 is a side view showing an example of an echelle grating;

Figs. 10a and 10b are a side view and a plan view respectively showing yet another embodiment of this invention utilizing a cylindrical mirror as a front mirror; and

Figs. 11a and 11b are a side view and a plan view respectively showing another embodiment of this invention utilizing a cylindrical mirror as a front mirror and inserted with apertured members.

BEST MODE OF CARRYING OUT THE INVENTION

Some embodiments of a narrow-band excimer laser of this invention will now be described in detail with reference to the accompanying drawings.

The narrow band excimer laser shown in Figs. 1a and 1b is made up of a front mirror 10, a laser chamber 20, and a diffraction grating 30 acting as a rear mirror, thus taking a so-called Littrow mount. In the laser chamber 20 KrF, etc. acting as a laser gas is sealed. For electrically discharging and exciting the laser gas, there are provided electrodes 23 and 24. Further, the laser chamber 20 is provided with windows 21 and 22 for transmitting the oscillated laser beam.

The purpose of the grating 30 is to select a beam of a specific wavelength by utilizing the diffraction of the beam. The grating 30 is provided with a plurality of tooth grooves arranged in a definite direction. In this specification, a direction perpendicular to these grooves is termed ruling direction of grating. Grating 30 can select a beam having the specific wavelength by varying angle of the grating 30 with respect to an incident beam in a plane including the ruling direction of the grating. More particularly, the grating 30 acts to reflect only a specific beam corresponding to the angle θ of the grating with respect to the incident beam in a predetermined direction, in this case the direction of the incident beam, thus effecting a selective operation of a beam having the specific wavelength.

This embodiment is characterized in that the arrangement of the grating 30 with respect to the electrodes 23 and 24 in the laser chamber 20 is selected such that the ruling direction of the grating 30 is perpendicular to the laser discharge direction between the electrodes 23 and 24 in the laser chamber 20.

Generally, the spreading angle of the laser beam transmitting through window 22 of the laser chamber is smaller in a direction perpendicular to the discharge direction than in the discharge direction of electrodes 23 and 24, that is, the direction of arrangement of electrodes 23 and 24. Therefore, by making the ruling direction of the grating coincide with the direction perpendicular to the direction of laser discharge, the spreading of the beam caused by the grating 30 can be made minimum.

This can efficiently narrow the bandwidth.

Another embodiment shown in Figs. 2a and 2b is constituted by a so called grazing incidence mount. In Figs. 2a and 2b and following drawings, parts having the same functions as those of the embodiment shown in Figs. 1a and 1b are designated by the same reference numerals. In the embodiment shown in Figs. 2a and 2b, the grating 30 of the embodiment shown in Figs. 1a and 1b is constituted by a grating 31 and a total reflection mirror 32. Other parts are identical to those shown in Figs. 1a and 1b. In the embodiment shown in Figs. 2a and 2b, the total reflection mirror 32 acts as the rear mirror of the narrow-band excimer laser and the grating 31 acts as a wavelength selection element which selects a laser beam having a specific wavelength. In the embodiment shown in Figs. 2a and 2b, electrodes 23 and 24, grating 31 and total reflection mirror 32 are arranged such that the ruling direction of the grating 31 is perpendicular to the direction of laser discharge between electrodes 23 and 24. As a consequence, the spreading of the laser beam projected in the ruling direction of the grating becomes a minimum. Thus, it is possible to minimize the spreading of the laser beam projected in the ruling direction of the grating, whereby it is possible to minimize the spreading of the beam at the grating 31. Thus the bandwidth can be narrowed at a high efficiency.

In the modified embodiment shown in Figs. 3a and 3b, prisms 41 and 42 constitute a beam expander which projects the laser beam outputted from the laser chamber 20 upon the grating 31 after expansion. In this modification, the ruling direction of the grating is perpendicular to the direction of discharge between electrodes 23 and 24 in the laser chamber 20. The direction of expanding the laser beam effected by prisms 41 and 42 (that is a direction perpendicular to the direction of an edge of the prism) coincides with the ruling direction of the grating 30, that is the direction perpendicular to the direction of discharge between electrodes 23 and 24 in the laser chamber 20.

By using a beam expander of this construction, the expanding angle at the grating 30 can be made smaller by a reciprocal of the percentage of expanding effected by the beam expander, thus increasing the line-narrowing efficiency.

In another modification shown Figs. 4a and 4b, a beam expander made up of prisms 41 and 42 shown in Figs. 3a and 3b is substituted by a beam expander made up of cylindrical lenses 43 and 44. In this modification too, the ruling direction of the grating 30 is perpendicular to the direction of discharge between electrodes 23 and 24 in the laser chamber 20. The beam expanding direction of the beam expander effected by the cylindrical lenses 43 and 44 is made to coincide with the ruling direction of the grating 30.

In a further modification shown in Figs. 5a and 5b, in place of the grating shown in Figs. 3a and 3b, grazing incidence mount is used comprising a grating 31 and a total reflection mirror 32.

In another modification shown in Figs. 6a and 6b, in place of the grating 30 shown in Figs. 4a and 4b, grazing incidence mount is used made up of a grating 31 and a total reflection mirror 32.

The embodiment shown in Figs. 5a and 5b is constructed such that the ruling direction of the grating 31 is perpendicular to the direction of discharge between electrodes 23 and 24 in the laser chamber 20 and that the direction of beam expanding effected by the beam expander including prisms 41 and 42 coincides with the direction of ruling direction of the grating 31.

The modification shown in Figs. 6a and 6b is constructed such that the ruling direction of the grating 31 is made to be perpendicular to the direction of discharge between electrodes 23 and 24 in the laser chamber 20, whereas the direction of beam expanding in the beam expander caused by lenses 43 and 44 is made to coincide with the ruling direction of the grating 31.

In another embodiment shown in Figs. 7a and 7b, a member 51 formed with an aperture is inserted between front mirror 10 and the laser chamber 20, and another member 52 formed with an aperture is inserted between the laser chamber 20 and grating 30 in the embodiment of Fig. 1. The apertures provided for members 51 and 52 have longer sides in parallel with the direction of discharge between electrodes 23 and 24 in the laser chamber.

Fig. 8 is a view as seen from the front mirror side in Fig. 7.

In Fig. 8, an aperture 51a is shown behind the front mirror 10, and the laser chamber 20 is shown behind the aperture 51a. The apertures 51a are rectangular in shape having longer sides in parallel with the direction of discharge between electrodes 23 and 24 in the laser chamber 20. The apertured member 52 inserted between the laser chamber 20 and the grating 30 has the same construction as the apertured member 51 shown in Fig. 8.

The spread angle of the laser beam outputted from laser chamber 20 is smaller in a direction perpendicular to the discharge between electrodes 23 and 24 than in the direction of the discharge, as has been described hereinabove. In the same manner as has been described in connection with the foregoing embodiments where rectangular apertures having longer sides in parallel with the direction of discharge, the laser beam emitted from the laser chamber can be efficiently transmitted, thereby minimizing the attenuation of the output level caused by the apertured members. In the embodi-

ment shown in Figs. 7a and 7b, two apertured members are inserted, but insertion of only one apertured member is sufficient. In the embodiments shown in Figs. 2a and 2b through Figs. 6a and 6b too, apertured members can be inserted in the same manner as in Figs. 7a and 7b.

In this case, the aperture is of a shape having longer sides parallel with the direction of laser discharge. It should be understood that the configuration of the aperture is not limited to rectangular but may be elliptical. Further, the aperture members can be inserted at one point or three or more points.

In the embodiments shown in Figs. 1a, 1b, 3a, 3b, 4a, 4b, 7a and 7b utilizing Littrow mount, use of an echelle grating as shown in Fig. 9 is advantageous as the grating 30. In Fig. 9, the top angle of each groove is substantially right angles, and as it is possible to manufacture a grating having a large blaze angle β, the echelle grating has a large efficiency and a large resolution. Consequently in the embodiments shown in Figs. 1a, 1b, 3a, 3b, 4a, 4b, 7a and 7b, where an echelle grating as shown in Fig. 9 is used, by making its blaze angle to coincide with the incident angle and diffraction angle of the laser beam, the bandwidth can be more efficiently narrowed. Thus, the bandwidth can be sufficiently narrowed with a single grating.

In still another embodiment shown in Figs. 10a and 10b wherein the front mirror 10 shown in Fig. 1 is replaced by a cylindrical mirror 60 which is disposed with it axis in alignment with direction of discharge between electrodes 23 and 24.

The radius of curvature of the cylindrical mirror 60 is selected such that the beam waiste of the laser beam reaches on the grating. More particularly, the radius of curvature of the cylindrical mirror 60 is selected such that an equation $R = 2L$ holds, where R represents the radius of curvature of the cylindrical mirror 60, and L represents the cavity length of the laser device, that is, the distance between the cylindrical mirror 60 and the axis of rotation of the grating 30. Furthermore, the axis of the cylindrical mirror 60 and the axis of the grating 30 are aligned with each other. As a consequence, narrowing of the bandwidth of the laser beam can be realized more efficiently.

Also in the embodiments shown in Figs. 2a, 2b through 6a and 6b by substituting the front mirror 10 with a cylindrical mirror 60 shown in Figs. 10a and 10b, narrowing of the bandwidth can also be made at a high efficiency.

In the embodiment shown in Figs. 10a and 10b, one or more apertured members can be inserted. One example of this construction is shown by Figs. 11a and 11b.

In the embodiment shown in Figs. 11a and 11b, an apertured member 51 is disposed between the cylindrical mirror 60 and laser chamber 20 and a similar apertured member 52 is disposed between the laser chamber 20 and grating 30. The aperture has an elongated configuration along the direction of discharge between electrodes 23 and 24 in the laser chamber 20 as shown in Fig. 8.

In a modified construction shown in Figs. 2a, 2b through Figs. 6a and 6b in which the front mirror 10 has been substituted by a cylindrical mirror shown in Fig. 10, one or more apertured members can be inserted as shown in Figs. 11a and 11b.

In various embodiments described above, it is not always necessary to make the direction of discharge between electrodes 23 and 24 in the laser chamber to be exactly perpendicular the ruling direction of the grating 30 or 31. So long as the ruling direction of the grating 30 or 31 is substantially perpendicular to the direction of discharge between electrodes 23 and 24, a wavelength control can be made with a sufficiently high efficiency.

Furthermore, it is not always necessary to exactly coincide the beam expanding direction effected by prisms 41 and 42 or cylindrical lenses 43 and 44 with the ruling direction of the grating 30 or 31. So long as the direction of beam expansion effected by a beam expander substantially coincides with the ruling direction of the grating 30 or 31, the wavelength control can be made at a sufficiently high efficiency.

In the construction where a cylindrical mirror 60 is used as a front mirror, so long as it is constructed that the axis of the cylindrical mirror 60 substantially coincides with the direction of discharge between electrodes 23 and 24, that the radius of curvature substantially satisfies with equation $R = 2L$, and that the axis of the cylindrical mirror 60 substantially align with axis of rotation of the grating control of the wavelength can be made at a sufficiently high efficiency.

APPLICABILITY TO INDUSTRY

According to this invention, it is possible to narrow the bandwidth at an extremely high efficiency. Furthermore, it is possible to provide a narrow band excimer laser with good durability. The narrow band excimer laser of this invention is especially suitable to use as a light source of a size reducing image projection light exposure device.

Claims

1. A narrow-band excimer laser operated by electric discharge excitation and utilizing a diffraction grating as a wavelength selective element, wherein said grating is disposed such that its

ruling direction is substantially perpendicular to a direction of electric discharge for the excitation.

2. The narrow-band excimer laser according to claim 1 wherein said grating is of a echelle type grating.

3. A narrow-band excimer laser operated by electric discharge excitation and utilizing a diffraction grating as a wavelength selective element and projecting a laser beam through a beam expander, wherein said grating and said beam expander are disposed such that a ruling direction of said grating and a beam expansion direction of said beam expander are substantially perpendicular to direction of the electric discharge for the excitation.

4. The narrow-band excimer laser according to claim 3 wherein said grating is an echelle type grating.

5. The narrow-band excimer laser according to claim 3 wherein said beam expander is constituted by a prism, an edge direction thereof being substantially parallel with a direction of the electric discharge.

6. The narrow-band excimer laser according to claim 3 wherein said beam expander is constituted by a cylindrical lens having a mechanical axis substantially in parallel with the direction of the electric discharge.

7. A narrow-band excimer laser utilizing a diffraction grating as a wavelength selective element, and disposing an apertured element in a laser cavity, wherein said grating is arranged such that a ruling direction of grating thereof is substantially perpendicular to a direction of electric discharge for effecting excitation, and an aperture of said apertured element is shaped as having longer sides extending in the same direction as said electric discharge.

8. A narrow-band excimer laser operated by electric discharge excitation, and utilizing a diffraction grating as a wavelength selection element, using laser beam to irradiate said grating through a beam expander, and disposing an apertured member in a laser cavity, wherein said grating and said beam expander are disposed such that a ruling direction of said grating and a beam expanding direction of said beam expander are respectively perpendicular to a direction of said electric discharge excitation, and wherein an aperture of said apertured member has a configuration having longer sides in parallel with a direction of said electric discharge.

9. A narrow-band excimer laser utilizing a diffraction grating as a wavelength selection element, wherein a cylindrical mirror is used as a front mirror of a laser cavity, and wherein said grating is disposed such that a ruling direction of grating thereof is substantially perpendicular to the direction of electric discharge.

10. A narrow-band excimer laser excited by electric discharge comprising a diffraction grating acting as a wavelength selective element, and means for irradiating said grating through a beam expander, wherein a cylindrical mirror is used as a front mirror of a light resonator, said grating and said beam expander are arranged such that a beam expanding direction of said beam expander and the direction of the electric discharge for excitation are respectively perpendicular with each other and wherein a mechanical axis of said cylindric mirror is substantially parallel with a direction of the electric discharge.

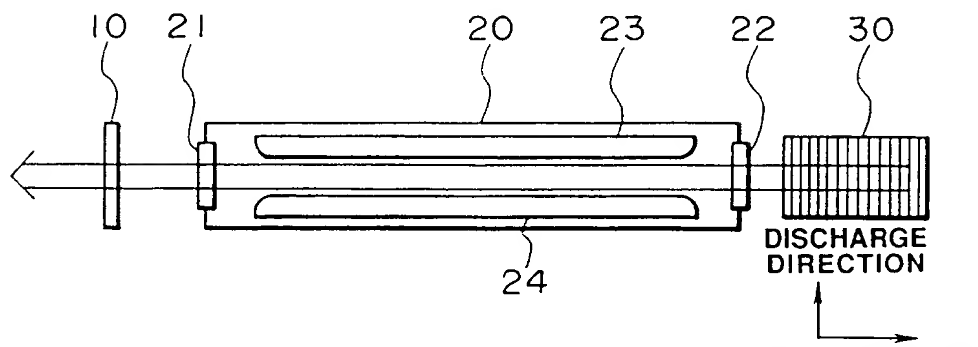
11. A narrow-band excimer laser excited by electric discharge comprising a grating acting as a wavelength selective element and an apertured member arranged in a light resonator, wherein a cylindrical mirror is used as a front mirror of said laser cavity, said grating is disposed such that the ruling direction of grating thereof is perpendicular to a direction of the electric discharge utilized for excitation, wherein said cylindrical mirror is arranged such that its mechanical axis is substantially parallel to said direction of the electric discharge, and wherein an aperture through said apertured member has an elongated configuration in the direction of said electric discharge.

12. A narrow-band excimer laser excited by electric discharge comprising a diffraction grating utilized as a wavelength selective element, means for projecting a laser beam upon said grating through a beam expander, and an apertured member located in a laser cavity, wherein a cylindrical mirror is used as a front mirror of said laser cavity, wherein said grating and said beam expander are disposed such that the ruling direction of said grating and a beam expansion direction of said beam expander are respectively perpendicular is the direction of electric discharge for said excitation, and wherein a mechanical axis of said cylindrical mirror is substantially parallel with

the direction of said electric discharge and an aperture of said apertured member has an elongated configuration substantially in parallel with said electric discharge direction.

13. A narrow-band excimer laser excited by electric discharge comprising a diffraction grating acting as a wavelength selective element, wherein said grating is constituted by an echelle type grating.

14. The narrow-band excimer laser according to claim 13 wherein said grating is arranged such that ruling direction of grating is substantially perpendicular to the direction of said electric discharge.


10
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23
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30
24
DISCHARGE DIRECTION
RULING DIRECTION OF GRATING

FIG.1 (a)

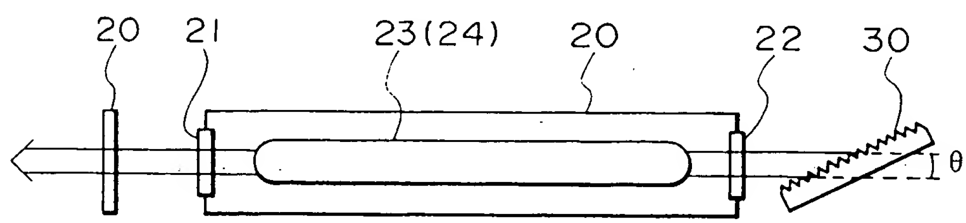
20
21
23(24)
20
22
30
θ

FIG.1 (b)

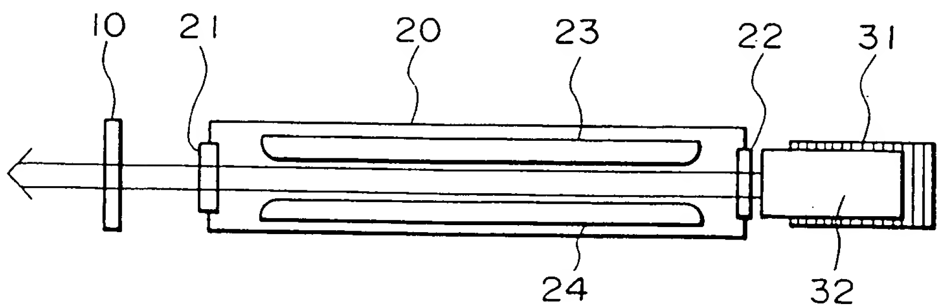

FIG.2 (a)

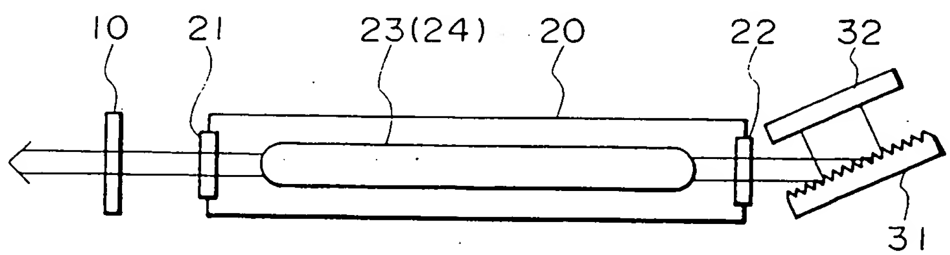

FIG.2 (b)

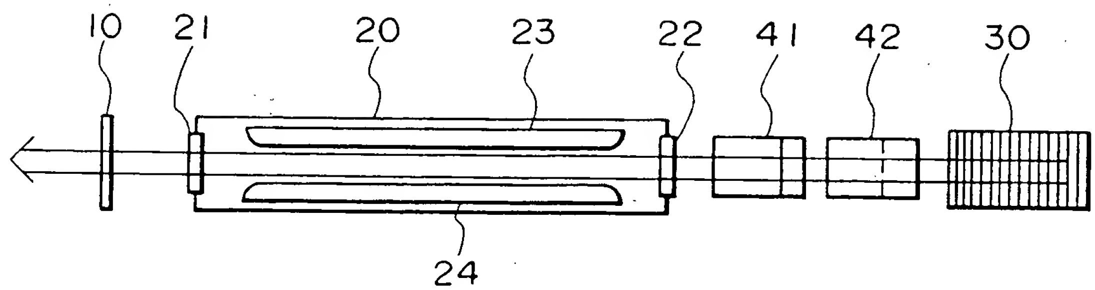

FIG. 3 (a)

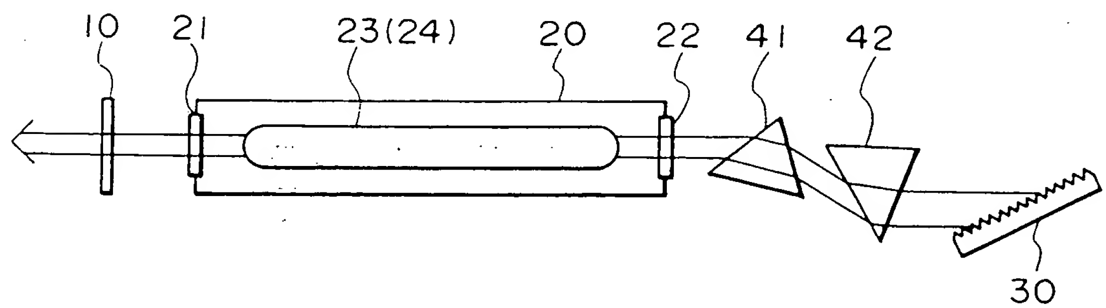

FIG. 3 (b)

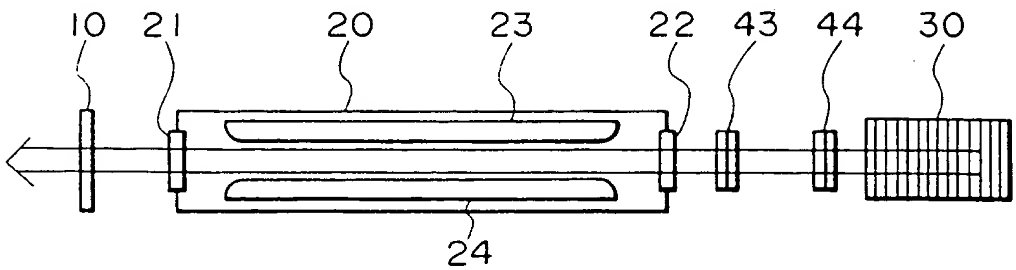

FIG.4 (a)

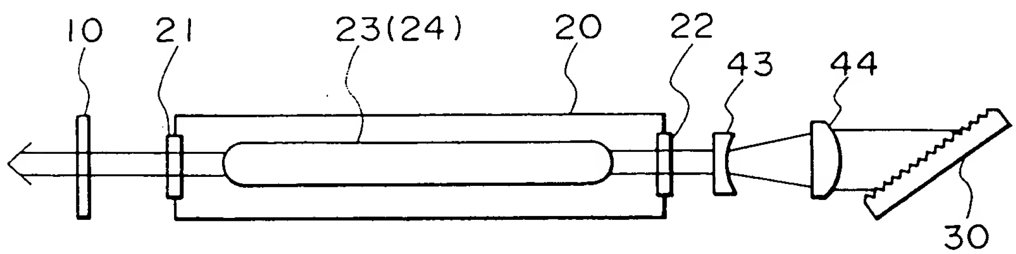

FIG.4 (b)

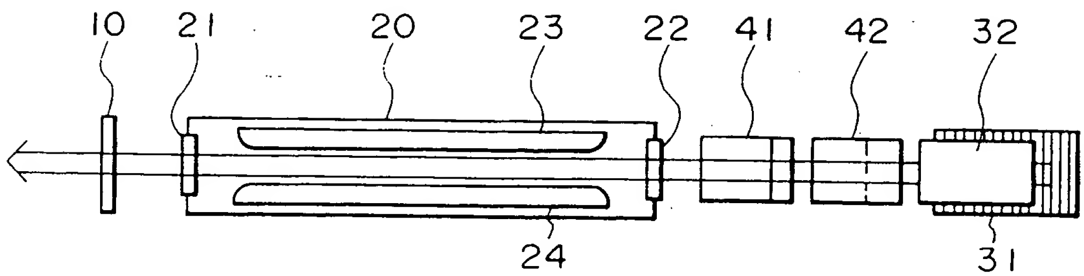

FIG.5 (a)

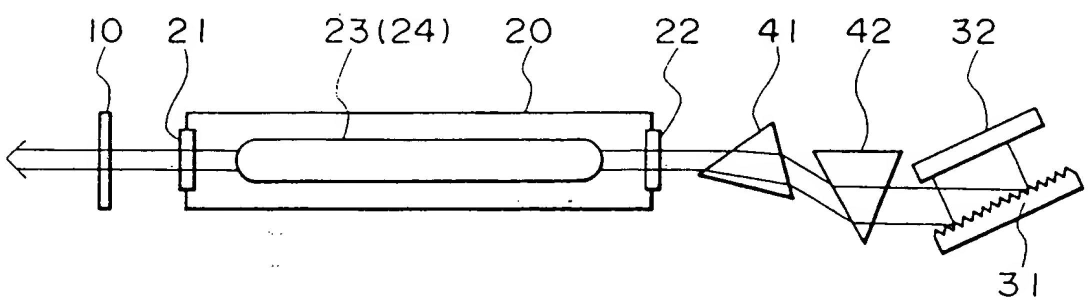

FIG.5 (b)

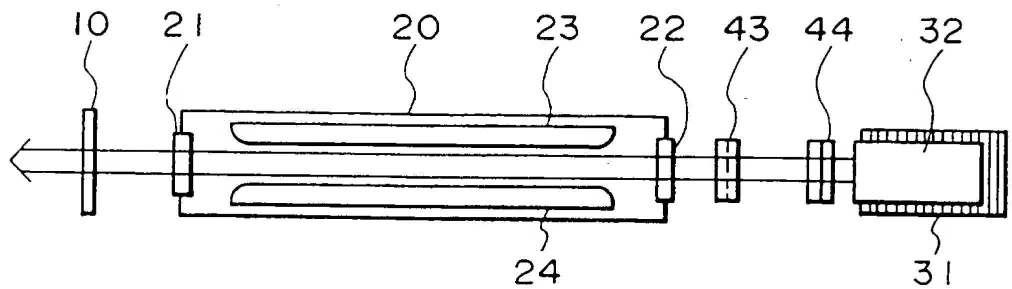

FIG.6 (a)

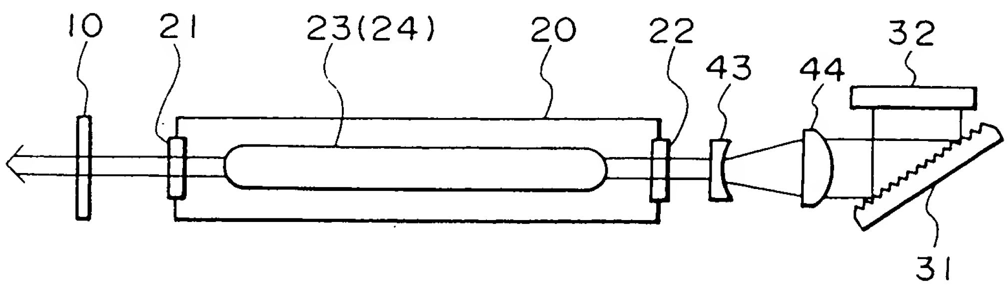

FIG.6 (b)

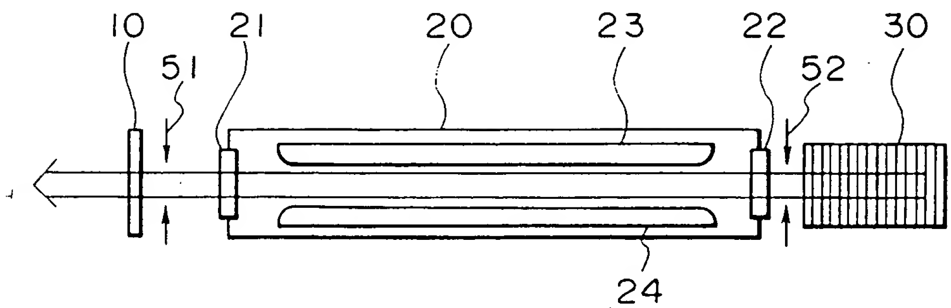

FIG.7 (a)

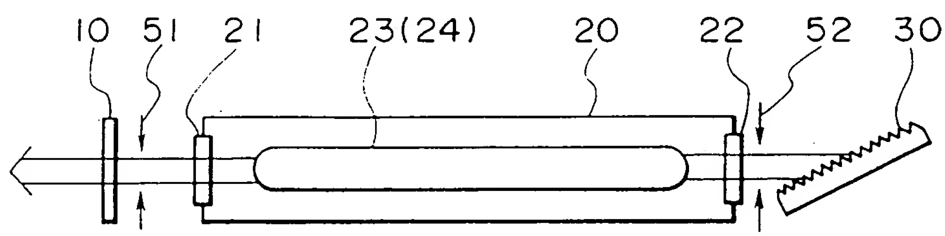

FIG.7 (b)

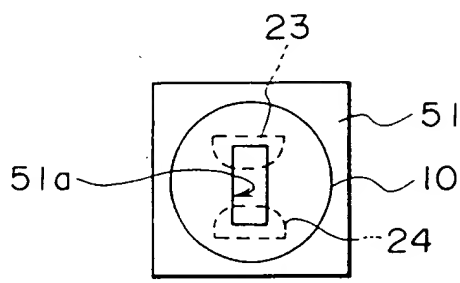

FIG.8

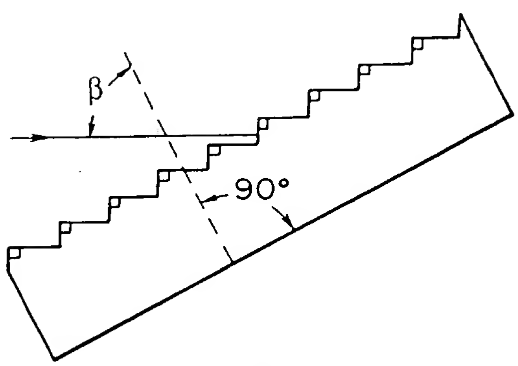

FIG.9

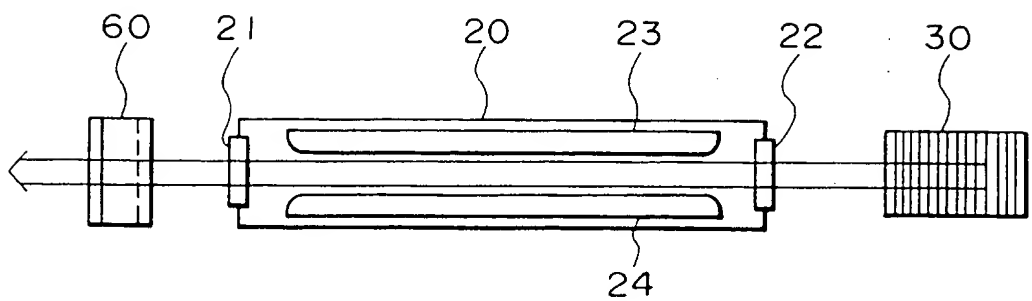

FIG.10 (a)

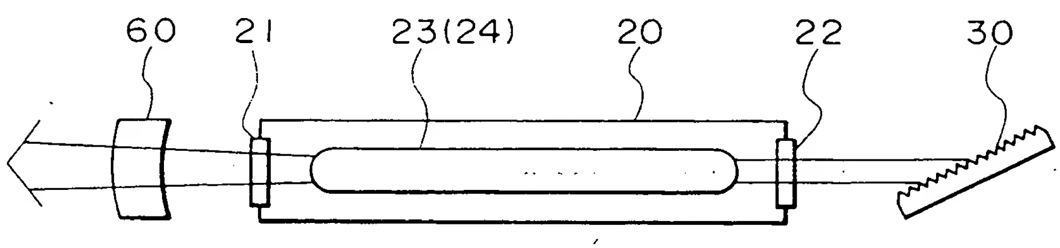

FIG.10 (b)

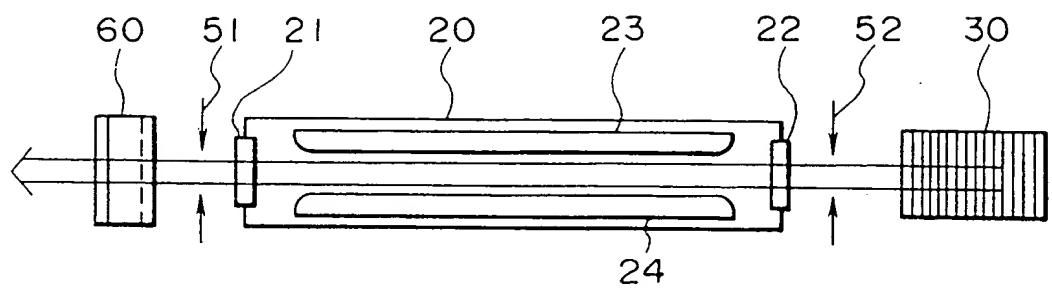

FIG.11 (a)

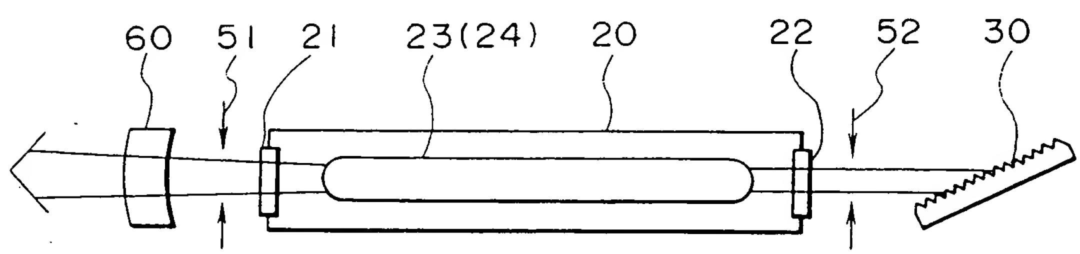

FIG.11 (b)

INTERNATIONAL SEARCH REPORT

International Application No PCT/JP90/00639

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl^5 H01S3/1055

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	H01S3/1055, 101, 139

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

Jitsuyo Shinan Koho	1926 - 1989
Kokai Jitsuyo Shinan Koho	1971 - 1989

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	JP, A, 59-84487 (Honeywell, Inc.), 16 May 1984 (16. 05. 84), Figs. 1, 5, 8 & JP, B2, 1-36987 & GB, A0, 8324111 & DE, A1, 3335317 & GB, A1, 2129201 & US, A, 4601036 & CA, A1, 1223949	1, 2
X	JP, A, 1-287978 (Shimadzu Seisakusho, Ltd.), 20 November 1989 (20. 11. 89), Figs. 1 and 5 (Family: none)	1, 2
A	JP, A, 51-17691 (Mitsubishi Electric Corp.), 12 February 1976 (12. 02. 76), Figs. 1 and 2 (Family: none)	1 - 14
A	JP, A, 51-20691 (Mitsubishi Electric Corp.), 19 February 1976 (19. 02. 76), Figs. 1 and 2 (Family: none)	1 - 14

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
July 30, 1990 (30. 07. 90)	August 13, 1990 (13. 08. 90)
International Searching Authority	**Signature of Authorized Officer**
Japanese Patent Office	